

Carbon Sequestration Risks According to EPA's 7/15/08 Proposed Rulemaking

What are the risks?

If Geological Sequestration projects are not managed properly there are general risks to:

- (Underground Source of Drinking Water) USDW's
- Air
- Human health
- Ecosystems
- Geomechanical/Geophysical

RISKS TO USDW's (Underground Source of Drinking Water)

The largest risk of geological sequestration (GS) is its affect on USDW's
It can affect USDW's in the following four ways:

- **Carbonic Acid** -Formed when CO₂ comes into contact with water- acidifies it, and acid causes naturally occurring metals (e.g. arsenic) to move into, and contaminate the water
- **Co-contaminants:** Hydrogen sulfide and nitrous oxides present in the CO₂ stream will endanger a USDW if high volumes of CO₂ are injected
- **Salinization:** Fluids injected in large quantities can potentially force salty water into USDW's
- **Movement out of the storage reservoir:** Injected CO₂ at high pressure can induce or open existing fractures which can increase movement through caprock, out of the storage reservoir, and into USDW's.

OTHER RISKS

HUMAN HEALTH

Released CO₂ at high concentrations can cause :

- Asphyxiation
- Increased breathing rate
- Vision and hearing impairment

ECOSYSTEM

1) Terrestrial

- Exposure to CO₂ can cause chronic and acute health effects in terrestrial mammals and birds
- Soil Acidity: changes resulting from increased CO₂ concentrations may adversely impact both plant and soil dwelling organisms

2) Aquatic

- Impedes fish respiration
- Causes decrease in PH to lethal levels
- Reduce calcification in shelled organisms
- Adversely affects photosynthesis of some aquatic organisms

GEOMECHANICAL/GEOPHYSICAL SEISMIC EVENTS

- **Reactivate dormant faults-** improperly operated injection of CO₂ could raise pressure in the formation causing earthquakes

Why we need a new program-what's different about CO₂?

UIC regulations currently define 5 classes of injection wells based on similarities in the fluids injected, construction, injection depth, design, and operating techniques. A new class of injection wells is necessary because:

Wells designated for geologic carbon sequestration differ from other wells in the following ways:

- CO₂ is buoyant and viscous
- Large volumes will be injected at high pressure
- Can endanger USDW's
- Additional construction requirements are necessary: GS well must maintain integrity and stability in CO₂ rich environment for the life of the GS project

Are there currently any GS sites and where are they located?

Sleipner Project-

- Located off Norwegian coast in the North Sea
- First commercial scale GS project into a saline formation
- 1 Million tonnes (Mt)^{*} CO₂ removed annually from the natural gas produced in nearby gas field
- Injected approx. 800 m below the seabed
- Project began in August of 1996
- Operators expect to store 20 Mt CO₂ over expected 25 yr. life of the project

In Salah Gas Project

- Central Saharan region of Algeria
- World's first large-scale CO₂ storage project in a gas reservoir
- CO₂ from natural gas field re-injected into three horizontal injection wells 5,906 ft. deep
- 1.2 Mt have been injected annually since April 2004
- 17 Mt will be stored over the life of the project

Weyburn EOR Project

- Beulah, ND
- CO₂ produced at coal gasification plant is piped to Weyburn in SE Saskatchewan for EOR
- 1.5 Mt injected annually
- Combination of vertical and horizontal wells
- 20 Mt CO₂ will be stored in the field over 20-25 yr. life of the project

Other projects:

Gorgon Gas Development- Barrow Island Western Australia: The Otway Project-Australia (saline formation), South Qinshu Basin -China (CBM sequestration project) CO₂SINK project-Ketzin Germany (sandstone saline formation)

* 1 Million tonnes= 1.2 tons

Sample of Risk Log

1. Siting	2. Construction	3. Operation	4. Closure	5. Post Closure	6. LT Maintenance & Stewardship
12-36 months	12-36 months	1-30 years +	12-36 months	Time limit or Performance driven	Indefinite post closure
1.1 Worker safety 1.2 Damage to private property 1.3 Incomplete site characterization 1.4 Public Opposition 1.5 Failure to obtain access or storage rights 1.6 Failure to obtain permit 1.7 Drilling "dry hole's"	2.1 Worker safety 2.2 Damage to private property 2.3 Damage to confinement zone (by fracturing a cap for example) 2.4 Contractor delays / cost over-runs 2.5 Poor well construction 2.6 Failure to adequately complete old wells/boreholes	3.1 Worker safety – OSHA 3.2 Worker safety – CO ₂ exposure 3.3 Groundwater: mechanical failure 3.4 Groundwater: confinement zone failure 3.5 Property damage (mineral rights) 3.6 Ecosystem degradation (terrestrial or aquatic)	4.1 Worker safety 4.2 Improper well abandonment 4.3 Failure to adequately install MMV system 4.4 Materials failure 4.5 Ecosystem degradation (terrestrial or aquatic)	5.1 Groundwater: CO ₂ and geochemical reaction products 5.2 Groundwater: brine or gas displacement 5.3 Subsurface property damage (mineral rights) 5.4 Public exposure to CO ₂ 5.5 Public exposure to CO ₂ 5.6 Atmospheric release 5.7 Lawsuits	6.1 LT groundwater contamination 6.2 LT Subsurface property damage (mineral rights) 6.3 LT ecosystem degradation (terrestrial or aquatic) 6.4 LT public exposure to CO ₂ 6.5 LT atmospheric release (loss of credits / compliance) 6.6 LT lawsuits 6.7 LT third party damage to confinement zone 6.8 Seismicity 6.9 Change in law

Addressing CSS Liability

Using a Risk Log to Better Define "Liability" and Consider Mitigation Options

Presentation to Edison Foundation

March 4, 2008

Washington, DC

Sarah Wade

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